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Scott Hippensteel

Rocks and Rifles

The Influence of Geology on Combat and Tactics during the American Civil War

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Advances in Military Geosciences

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Preface

I grew up on South Mountain, Pennsylvania, about 20 km from Gettysburg. Legend had it that the members of my mother's family hid in their attic and watched Lee's army march by their Cumberland Valley farmhouse during his famous invasion. As a young man, I spent countless hours hiking and biking around the nearby battlefield. My favorite place to visit was Little Round Top and Devil's Den, at daybreak in the spring and fall, when I could have the battlefield to myself.

As an undergraduate in college, I was torn between history and science. I knew I wanted to be a college professor, but could not decide on a field of study. My father, a mathematics professor, convinced me to pursue the natural sciences, largely out of concern for my future job prospects. And so I became a geologist, pursuing my Master's and Doctoral degrees at the University of Delaware.

During much of my 22 years in graduate school,[1] I commuted weekly between Richmond, Virginia, and Newark, Delaware. This travel provided many opportunities for half-day visits to the numerous Civil War battle sites of Northern Virginia, solidifying my fascination with my two favorite subjects of study: military history and geology. I was especially interested in the intersection between the two—how geology influenced the tactics and strategy of the American Civil War. Each of these battlefields provided a different example, or many examples, of how the rocks influenced the fighting. This book explores these examples at different scales.

I concede that I am a geologist first, writing from a natural sciences perspective about history. I am not a military historian, although I have always chosen to read books about military history over earth history. As a geologist, I choose to organize this text around the three primary types of rocks, with individual chapters focusing on battles in chronological order. I selected battles where the influence of geology on the combat and tactics was straightforwardly demonstrated. Many important battles, where the rocks played a lesser role, are mentioned only in passing (i.e., Chancellorsville, Wilderness, Shiloh).

Each battlefield chapter discusses the strategic situation prior to the campaign and then explores the geology of the battleground, followed by the history of the

[1] Duration of my time in graduate school provided by my wife

fighting. The final portion of each chapter is the most important—an analysis of how the rocks influenced the strategy, tactics, and combat. As organized, the discussion of geology and fighting shifts from larger-scale, strategic influences to smaller-scale, battlefield tactics. The final portion of each chapter discusses geology on the smallest (individual) scale, ranging from rock-throwing to the influence of sand on weapons and fortifications. Other than the Introduction and Conclusion chapters, only one chapter of the book varies from this organizational scheme. I found the research on geology and Civil War photography to be wholly fascinating and thus choose to include it—despite the variance from the organizational tenets of the book—as the second chapter on Gettysburg.

Perhaps the most important contributions of this book are the numerous illustrations. The Library of Congress was a terrific resource for extremely high-resolution images from 1861 to 1910, and I have enlarged, cropped, and sharpened the details of many of these negatives to add to the narrative. The block diagrams included in each battlefield chapter are a first of their kind. They are inserted to provide the reader with a geologic framework for the battleground—a schematic understanding of how the rock types influenced the landscape. Vertical exaggeration is great in these three-dimensional drawings and varies between battlefield illustrations; nevertheless, a comparison of these diagrams and the later included maps of troop positions and movements best illustrates the influence of the underlying geology on the combat.

Finally, this book would not have been possible without the patience, support, and encouragement from my wife Kyra. Over the years her critiques of my manuscripts (too many parentheses) have made me a better writer. Twenty-five years ago, I took her on a hike through Devil's Den and the Valley of Death at Gettysburg, *for our second date*. I will always be indebted to her for her willingness to share so much time with me on these battlefields and to tolerate so many dinnertime discussions (lectures) on everything from artillery trajectories to differential weathering of igneous rocks.

Charlotte, NC, USA
August 2018

Scott Hippensteel

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Chapter 1
Introduction

"The nature of the ground is the fundamental factor in aiding the army to set up its victory."

—Mei Yao-Ch'en, 1002–1060

Abstract The terrain in the Eastern and Western Theaters of the Civil War was created by geological forces operating during the last billion years of Earth's history. The construction, and eventual disarticulation, of the supercontinents of Rodinia and Pangea led to the creation of five physiographic—or geological—provinces in eastern North America and each of these provinces provided vastly different landscape characteristics that could be exploited on multiple scales by the commanding officers. This chapter explores how the different geology, and resulting terrain, of each province influenced fighting at multiple scales: Strategic, tactical, and close-quarters combat.

Keywords Geology · Civil War · Terrain · Physiographic provinces · Geological history · Great Valley · Strategy · Tactics · Combat · Scale

1.1 Geology and the Combat Experience of Union Private William Tritt

William Tritt was, in many respects, a typical American Civil War soldier, although the influence of geology on his combat experiences may have been greater than that of the majority of soldiers who served on either side during the war. William stood 1.7 m tall (5-ft 7-in.) and weighed a little under 70 kg (150 lb). He was a carpenter and farmer from south-central Pennsylvania who enlisted when he was 20 years old. Less than 2 months after joining the Union Army as part of Company D of the 130th Pennsylvania Regiment, "Penn's Volunteers", he was in combat in Maryland. The 130th was attached to the 2nd Brigade, 3rd Division of Brigadier General William French's II Corps, which

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made the initial assault on the famous sunken road at the center of General Robert E. Lee's line at Antietam during the afternoon phase of the 1-day battle.

I had always had a particular interest in this famous assault, and especially the experience of the 130th Pennsylvania, because William Tritt was a (distant) relative. I never contemplated how geology affected his time in combat or his probability of survival until I visited the Antietam battleground and retraced the path his regiment had followed as it progressed across the rolling farm fields towards the Confederates holding the sunken road.

Historical accounts of the battle describe the sunken road as a nearly ideal defensive position—essentially a pre-dug trench with a crude small parapet constructed from disassembled split-rail fencing. I had envisioned William and his comrades' approach on this strong position having occurred under sustained Confederate artillery and small-arms fire, with much of the rifle fire coming from the infantry concealed in the road. In my mind the approach of the 130th would have been somewhat similar to that of another division of the II Corp that had attacked, and been decimated, only hours earlier and a kilometer away during Major General Sedgwick's morning attacks towards the Dunker Church. Instead, when I walked the route of the 130th Pennsylvania's attack, I realized I could never actually see the sunken road. The path of approach of the 130th was almost entirely concealed from the Confederates by a long, winding ridge that made the assault markedly safer (Fig. 1.1). The reason for this concealment and increased degree of safety could be directly attributed to one factory: geology.

Fig. 1.1 The sunken lane at the center of the Confederate line at Antietam (left, shaded gray) and the approach of French's division (arrow). Note the linear dolostone ridge paralleling much of the sunken lane

William's commanding officers had effectively exploited the local geology, always keeping harder rocks and higher ground between the Union infantry and the Confederate line. This concealment continued until the 130th climbed the reverse slope of the hard-rock ridge to find themselves less than 100 m from the sunken road and in a perfect enfilade position above the lane (Fig. 1.2).

At Antietam, the II Corps suffered more than any other Corps to see combat. Of the three division within the II Corps, casualty numbers were disparate: Sedgewick's 2nd Division suffered more loss than the other two Corps combined. The reason for this different magnitude of killed and wounded can also be directly related to geology, and specifically the differential weathering of the rocks around Antietam.

Sedgwick's unfortunate and ill-planned morning attack took place across the Conococheague limestone, a formation of rock known for its consistent rate of weathering and propensity to produce flat, gently-sloping terrain (Fig. 1.3). This landscape is easier to defend, with longer sightlines for infantry and artillery and a gentle incline encouraging ricocheting or grazing artillery solid-shot. The Union assault was unsurprisingly especially costly.

In contrast, the rolling terrain over which William Tritt, the 130th, and the 3rd Division marched was created by differential weathering between softer limestone, producing swales, and harder dolostone, producing ridges. This later Union assault took full advantage of the weathering characteristics of the rocks, tracking their approach entirely in the softer limestone swales until approaching the harder dolos-

Fig. 1.2 View from the crest of the dolostone ridge towards the sunken road. Enfilade fire from this position into the length of the lane removed much of the advantage the pre-existing "earthworks" offered by the sunken road to the defending Confederates

Fig. 1.3 Flat, only slightly undulating over which the Union assault during the morning phase of the Battle of Antietam took place. Sedgewick's men marched across this field towards the Dunker Church and Stonewall Jackson's men on the horizon

tone ridge for the final assault. The Confederate defenders of the lane couldn't see the approaching Union infantry until it was too late for long- and intermediate-range fire (400–100 m), and soldiers can't efficiently wound and kill an enemy they can't see.

The dolostone ridge proved highly advantageous to the 130th Pennsylvania, and their adjacent regiments the 5th Maryland, 14th Indiana, and 8th Ohio, even during the final combat phase of the engagement. The Union infantry fired from the top of the ridge before retiring a few meters down the reverse slope of the hill to reload under the cover of the hard(er)-rock ridge. The results of the firefight for the Confederates was predictable in such a tactically disadvantageous position, and there is a good reason their "nearly ideal defensive position" in the sunken road was renamed "Bloody Lane" after the fighting ended (Fig. 1.4).

The probability of surviving combat is determined by a myriad of parameters, and the 130th Pennsylvania did not leave Antietam unscathed. The regiment lost 178 men during the battle, with 32 killed on the field and 14 dying later. Nevertheless, it is inarguable that William Tritt, and the regiment he joined, were fortunate to be in a part of the afternoon assaults on the center of Lee's line, when Union commanders exploited the geology, instead of during the morning phase of the battle, when they ignored it. Unfortunately, within 3 months the men from Pennsylvania would

Fig. 1.4 Confederate dead in the Bloody Lane. Edited and enhanced photo from the Library of Congress Ref. LC-DIG-ds-05168; original photograph by Alexander Gardner

find themselves marching towards Marye's Heights, a terribly disadvantageous position with respect to geology, as part of General Burnsides' calamitous massed assaults at Fredericksburg.

1.2 Rock Types and Resulting Terrain

Effective use of terrain was a critical aspect of command that determined the success or failure of an army on the battlefield during any war. No single factor contributed more to the nature of the terrain—slope, roughness, outcrops, sinkholes—and the potential for successful defensive and offensive tactics than geology. Geology also determines the ease of digging entrenchments and the source materials available for construction of breastworks, parapets, or larger fortifications.

Geology, geomorphology,[1] and rock-weathering and their influence on combat and tactics is a topic largely neglected by historians. Consider, for example, the debate about why the massive First World War network of trenches didn't appear, at least on a large scale, on Civil War battlefields until the war was almost half over. Traditional historical thinking attributed this lack of entrenchment to the commanding officer's reluctance to allow citizen-soldiers to have something to shelter behind

[1] The study of landforms.

or in—any potential concealment would induce a reluctance for aggressive offensive action by the infantry, diminishing their willingness to leave their fortifications for attack or counter-attack. This hypothesis neglects a geologic context, however. On several early Civil War battlefields the thin soils, shallow bedrock, and outcropping rocks made entrenching impossible, even if the soldiers had been ordered to do so.

Most people who study the Civil War will be familiar with the three primary types of rocks: Igneous, metamorphic, and sedimentary. Fewer might possess a comprehension of how these rock types were created, weather, and influence battleground terrain. Terrain, relief, and roughness (outcrops) are determined by a combination of geology and climate. Of these two factors, it could be argued that on most battlefields geology is the more significant of the two.

Compare, for example, the influence of geology on the fighting around Charleston, South Carolina, during the war. The geomorphology of the islands and the abundance of sand for defensive works proved incredibly beneficial for the defending Confederate army. This geology could hardly be more dissimilar to the ancient rocks underlying the battlefields of Virginia only 600 km to the north. The climate was certainly different, but the influence on terrain was hardly comparable because of the limited variability in temperature and precipitation (Average annual temperature and rainfall: Charleston, SC—13.1 °C, 129 cm; Appomattox, VA—13.2 °C, 118 cm). In short, geology had more of an influence on terrain, landscape, and combat and tactics, than climate.

Each rock type forms and weathers differently. Igneous rocks, which crystallize from liquid magma, comprise the vast majority of the earth's crust (Prothero and Schwab 2004), but are much less common on the surface of the planet. The molten rock (magma) is called lava when it reaches the Earth's surface. The rate of cooling determines the rock's grain size, with slower cooling magma—that usually cools slowly inside the Earth (intrusive)—having larger crystals than fine-grained rocks that cool quickly close to or on the surface (extrusive).

Igneous rocks tend to be durable and resistant to chemical and mechanical weathering because of their dense crystalline structure and high silica content. Light colored igneous rocks like granite or rhyolite will be largely composed of silicate minerals, including quartz and feldspar. These light colored felsic rocks are lower in density than darker intermediate or mafic rocks. Intermediate igneous rocks are composed of a little over 50% silica. Mafic (very dark or black) igneous rocks have less silica than felsic rocks and are denser. Both the increases in density and darkness are related to their higher iron and magnesium content, with dense minerals like olivine, pyroxene, and amphibole being common components.

Because of their durability and resistance to weathering, igneous rocks often express themselves on the landscape in the form of ridges or domes. Examples from Civil War battlefields are not abundant but are historically significant: Little and Big Round Top at Gettysburg are both underlain by mafic igneous rocks, as are Cemetery Ridge, Seminary Ridge, and Culp's Hill. At Second Manassas, the critical Confederate defensive position along an unfinished railroad grade was also anchored on igneous rocks.

Metamorphic rocks are pre-existing rocks that have been altered by increases in heat and pressure. Any type of rock, sedimentary, igneous, or another metamorphic rock, can be metamorphosed or changed if exposed to enough heat or pressure. Metamorphic rocks are exposed on the Earth's surface at about the same frequency as igneous rocks, but they are more common on Civil War battlefields. Kennesaw Mountain, Georgia, is a mountain because of its tough outcropping metamorphic rocks. Many of the rocks under the Chancellorsville and Wilderness battlefields in Virginia have also been metamorphosed during ancient continental collisions.

When metamorphism occurs over a wide geographical area, as with tectonic movements or collisions of large land masses, regional metamorphism is produced. This creates foliated textures in the rocks where the mineral crystals become aligned, as with the rocks slate, schist, and gneiss. On a smaller, more localized scale, rocks can be altered or baked if they are very close to, or come in contact with, magma or lava. This phenomenon produces contact metamorphism in the zone of rock that was altered by heat. The pre-existing sedimentary rocks at Gettysburg were metamorphosed by the later igneous intrusions into the area. The result was a ring of contact metamorphism surrounding Cemetery and Seminary ridges producing a rock called hornfels. The sequence of rocks observed in the famous railroad cut north of town is typical of a contact metamorphism zone: Unaltered shale is found to the west adjacent to hornfels (contact metamorphism) which is adjacent to the diabase igneous intrusion (ridge) which is adjacent to a second layer of hornfels and shale—the diabase dike has metamorphic and sedimentary rocks on both flanks.

Sedimentary rocks are composed of weathered clastic or detrital particles of other rocks or chemical precipitates of material that had been dissolved in water. Clastic sedimentary rocks are classified based on their particle size. Sandstone is composed of sand, siltstone of silt, and shale is composed of clay. Mudstones have both mud and silt and graywackes, or "dirty" sandstones, contain sand, silt, and clay. Chemical sedimentary rocks are often composed of calcium-carbonate ($CaCO_3$). Clastic and chemical sedimentary rocks are the most common types of rocks on the Earth's surface and on most battlefields (Prothero and Schwab 2004) (Fig. 1.5).

The topography produced by sedimentary rocks is usually a function of how hard the rock is, how it reacts to mechanical and chemical weathering, and how much the strata is tilted. All rock types can be broken down by both types of weathering, but sedimentary rocks are most susceptible to chemical weathering because of their carbonate composition or cement. This is why limestone and marble (metamorphosed limestone) monuments and tombstones are more easily etched and weathered by acid rain when compared to ornamental stones composed of igneous rocks like granite or rhyolite.[2] In general, limestones tend to be more vulnerable to chemical weathering than dolostones and clastic rocks with calcite cement tend to be easier to break down than those with silica cement.

Mechanical weathering, or physical weathering, occurs through abrasion when rock is exposed to water, wind, ice (expansion), and pressure. Glaciers can also cut

[2] Granite and rhyolite are essentially the same rock, in terms of composition, but granite is coarse-grained and rhyolite cooled more quickly, producing a fine-grained texture.

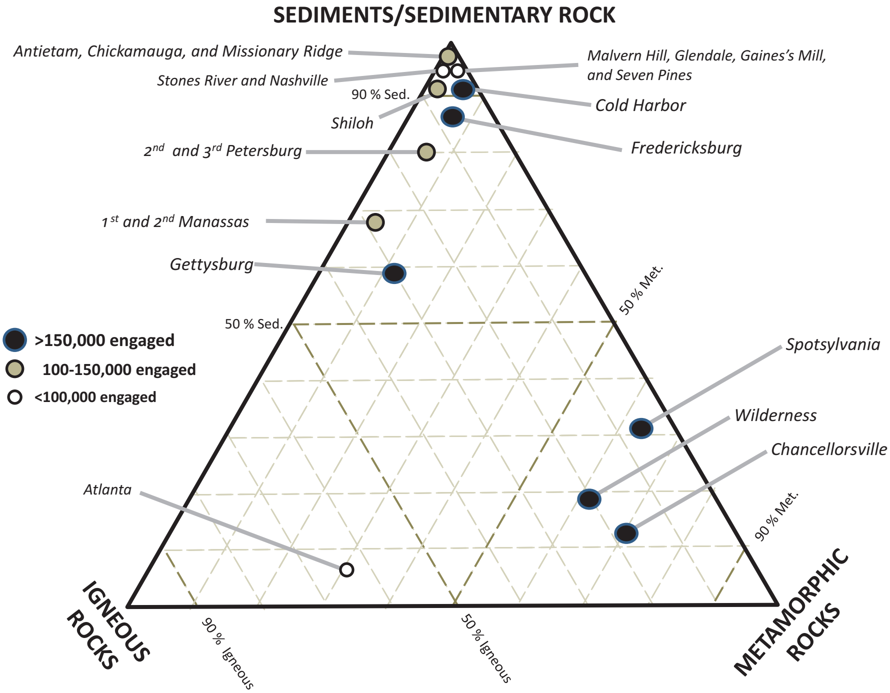

Fig. 1.5 Ternary diagram showing the prevalence of sedimentary rocks on the 20 most important (as defined by troops engaged) battlefields from the Civil War. Circle-diameter and fill relates to the size of the engagement

and abrade rocks, although this process is unknown on Civil War battlefields. One of the more common types of mechanical weathering on battlefields is exfoliation, where the expansion and contraction of the rocks causes the outer layers to peel away. This process leaves the rocks especially vulnerable to ice-wedging, where water percolates into small fractures, freezes and expands, and increases the fracture size. This process is particularly common on battle sites from the Mid-Atlantic (e.g. Gettysburg, Monocacy, Antietam) where daily temperatures often fall below and rise above the freezing point, producing daily freeze-thaw cycles.

Chemical weathering usually works in conjunction with mechanical weathering, enhancing the effectiveness of both destructive processes on sedimentary rocks. Carbonates like limestone and dolostone are particularly vulnerable to dissolution from slightly acidic rainwater (pH 5.6 on average). On battlefields underlain almost exclusively by carbonate rocks (e.g. Chickamauga, Franklin, Nashville, Antietam, Cedar Creek), the specific kind of carbonate rock or rocks being eroded will have a strong influence on terrain. Consistently weathering, soft limestones produce undulating landscapes with gentle slopes, while combinations of soft limestone and harder dolostones produce more rolling terrain, with multiple ridges, hills, and swales (Ehlen and Whisonant 2008).

Clastic sediments and sedimentary rocks can also produce dissected terrain (with many stream valleys) and prominent ridges. The expression of the rocks on the landscape will primarily be a function of two factors: the tilt of the formations and the degree of cementation and lithification. Petersburg, for example, is underlain by unconsolidated or partially lithified rocks, which have a gentle dip towards the east. This produces slightly oscillating terrain and softer strata that can be tunneled through. Although hills are common and stream valleys more so, distinct hard rock ridges that prohibit tunnels do not exist in this portion of Virginia, south of Petersburg.

The battlefield at Fredericksburg, Virginia, has a landscape created by differential weathering and river erosion that is a direct function of the degree of cohesion in the clastic sediments and rocks. Clay-rich sediments and partially cemented sedimentary rocks produce terraces along the edge of the ancient path of the Rappahannock River, and these terraces were the heights above the city that Lee and Jackson selected for their army's defensive line. Burnsides' unfortunate infantry crossed the river to attack upslope from land underlain by the flat, unconsolidated, younger fluvial deposits left behind by the meandering river.

Lookout Mountain, in comparison, is capped by very hard and strongly cemented, quartz-rich sandstone. The dip of this formation, and the softer rocks beneath, produced a high-relief ridge and an imposing defensive position for the Confederates overlooking Chattanooga. Nearby, Missionary Ridge was also created by differential weathering, but while Lookout Mountain had clastic and carbonates weathering at different rates to produce contrast, the rock along Missionary Ridge are entirely carbonates. Missionary Ridge was created by differential weathering between weaker, purer limestones and harder limestones enriched with chert (silica).

Perhaps the most interesting landscapes, from a tactics perspective, are those created when different categories of rocks are mixed across a battlefield. The resulting differential weathering between much more durable igneous and metamorphic rocks and weaker sedimentary rocks produced terrain that was immensely defendable. Pickett's Charge on the 3rd and final day of the Battle of Gettysburg was launched from one igneous-rock ridge, crossed a large, flat sedimentary plain, before collapsing against another igneous-rock ridge. At Second Manassas a similar assault, this time by the Union, repeated this repetition in rocks, where infantry attacked from sedimentary rocks against Stonewall Jackson's defensive position underlain by igneous rocks.

Nevertheless, different rock types from the same category (limestone/dolostone, shale/sandstone, slate/gneiss) also produce landscape features like ridges or stream fords that could be exploited by a skilled tactician. One of the underlying goals of this book is to explore how the expression of rock-type and weathering on the battlefields differed, and how these differences were exploited by soldiers of all ranks.

Fig. 1.6 Five physiographic provinces, each with different geology and relief, are found in the Eastern Theater of War. The base map depicts the path of the NE and SW Alabama Railroad, published in the decade before the Civil War. *BR* Blue Ridge Province

1.3 Geological Provinces of the Eastern United States

1.3.1 Eastern Theater of War

The Appalachian Mountains provided a barrier for the movement of large bodies of troops and defined the two primary north-south corridors between the Union and Confederate states. In the east, the mountains and terrain can be divided into five physiographic, or geologic, provinces. The Appalachian Plateau, the Valley and Ridge, the Blue Ridge, the Piedmont, and the Coastal Plain (Fig. 1.6).[3] Each province had different effects on the strategy and tactics employed by both armies, and each also produced multiple logistical challenges to the armies in the field.

[3] Hoyer & Ludwig, and North East and South West Alabama Railroad. *Map showing the N.E. & S.W. Alabama R.R. with its connections also the principal routes between New York and New Orleans*. [Richmond, Va., 1853–1854] Map. Retrieved from the Library of Congress, https://www.loc.gov/item/98688742/. (Accessed September 23, 2017.)

As the name implies, the Appalachian Plateau is composed primarily of flat or gently dipping sedimentary rocks. Dendritic drainage patterns form around these plateaus, producing valleys for the streams and rivers that resemble a branching tree when viewed from above. This dissected terrain dictates that movement by infantry and artillery will only be easy in relatively random directions along the top of the plateaus because conducting coordinated movements across stream or river valleys with anything larger than a company of men would be difficult. In short, although the Appalachian Plateau saw several harsh skirmishes during the war, large troop engagements or invasions by armies were mostly prohibited by the terrain.

In contrast, the Valley and Ridge province, which lies to the east of the Appalachian Plateau, was the region of the country that provided the most favorable corridors for invasion. This geological province is defined by multiple high-relief, hard-rock mountain ridges rising above flatter, softer, carbonate-rich valleys. The southwest-northeast orientation of these valleys led from western Virginia into central Pennsylvania. This alignment favored the Confederacy in two ways: First it provided a protected route for invasion towards important northern cities like Harrisburg and Philadelphia. The steep mountain ridges could only be crossed at lower elevation gaps in the high ridges, and these could be guarded and defended with a relatively small force of infantry, freeing the rest of the army for maneuver. Secondly, the orientation of the mountain chain protected Lynchburg, Charlottesville, Richmond, and Petersburg from Union advance from the north and west. Any army approaching these strategically important Confederate cities, or the capital, from this direction would need to cross multiple linear mountains at a number of different gaps, dividing the force and leaving it vulnerable to isolation and attack in detail by a larger and more concentrated southern army.

Older and harder rocks underlie the next province to the east, the Blue Ridge. This long, narrow mountain range represents the metamorphosed core of an ancient mountain system and, as with the mountains in the Valley and Ridge Province to the west, passage by an army through the chain is difficult if not prohibitive. This makes the gaps in the Blue Ridge Mountains, whether dry or carved by rivers, strategically important points. During the Antietam Campaign, for example, three different battles were fought in the passes of Maryland's South Mountain: The Battles of Crampton's, Turner's, and Fox's Gaps.

The gaps in the Blue Ridge are usually erosional in nature, although three passes critical to the concentration of the Confederate army at Gettysburg—Cashtown, Fairfield, and Carlisle—were formed by a combination of erosion and faulting (Brown 1962).

The next province to the east, the Piedmont, begins at a dramatic drop in elevation at the edge of the neighboring Blue Ridge. This large change in elevation is called the Blue Ridge Escarpment and this slope was a significant challenge to the transport of wagons or artillery. The Piedmont is characterized by gently sloping or rolling terrain with occasional monadnocks, or isolated hard-rock hills or small mountains (Fig. 1.7). Pilot Mountain and the Uwharrie Mountains in North Carolina and Sugarloaf Mountain and Willis Mountain in Maryland and Virginia are four such rises, and all offer ideal observations points for scouts on reconnaissance.

Fig. 1.7 Cedar Mountain, Virginia, is an excellent example of a monadnock. The 1862 Confederate victory was a prelude to the larger Battle of Second Manassas and took place on the fields below the mountain, not the isolated peak itself

The western portion of the Piedmont has a different, and more interesting geological history than the metamorphic eastern half. While the eastern Piedmont was primarily formed and altered by tectonic collisions, the western portion was created through stress from extensional forces. Around 220 million years ago the supercontinent of Pangea was rifting apart. On the landscape of the western Piedmont, massive faults created basins which quickly filled with oxidized iron-rich sediments, producing red sandstones, siltstones, and shales. At roughly the same time, magma intruded into and around this stretched and fractured crust, crystallizing into diabase dikes (if the intrusion cut across the strata) or sills (if the molten rock cooled and crystallized concordantly and parallel with the older sedimentary layers of rock). Two important battlefields from the Civil War are found in these Triassic basins—Manassas and Gettysburg—and evidence from this rifting is abundant in the form of diabase outcrops (Devil's Den, Little Round Top) and rich, red soil.

The Piedmont begins at the abrupt drop of the Blue Ridge Escarpment and ends at another dramatic change in elevation: the Fall Line. The Fall Line (or more properly, Fall Zone) marks the shift in rock type from the hard metamorphic and igneous rocks of the Piedmont to the weakly lithified sedimentary rocks and sediments of the Coastal Plain. The drop in elevation at the eastern extent of the harder rocks produces waterfalls, and these are the first falls encountered as a traveler moves upriver across eastern North America.

At this point, early settlers navigating upriver by boat from the Atlantic would find the river no longer passable and would transfer to some terrestrial form of transport—wagon or eventually train. Cities soon developed around these transportation hubs, including Columbia, South Carolina, Raleigh and Roanoke, North Carolina, and Washington D.C. Major battles were fought around other cities on or very near to the Fall Zone, including Fredericksburg, Richmond, Petersburg, and Bentonville.

Strategically the Fall Zone was important for reasons beyond the differences in rock type and terrain between the east and the west. Rivers were easier to ford on the Piedmont, and pontoon bridges or boats were needed to cross the deeper, meandering rivers of the Coastal Plain. Digging was also easier on the Coastal Plain. Trenching and construction of parapets was usually faster on the Coastal Plain because of the great depth of bedrock and the sandy, unconsolidated sediments. Larger engineering features like the enormous meander cutoff canal called Dutch Gap on the James River would have been impossible west of the Fall Line.

The Coastal Plain begins at the Fall Zone and thickens as a sedimentary wedge towards the Atlantic Ocean. The igneous and metamorphic rocks under the Coastal Plain also deepen towards the Atlantic Basin and are similar in composition and age to the provinces found to the west.

The primary source of sediment for this massive wedge of clastic particles was the eroding Appalachian Mountains. As the mountains weathered and their eroded pebbles, sands, and silts were carried downhill by rivers to the south and east, the mountains slowly rose in response to the decrease in weight and overburden. Rising rock erodes quickly, and eroded rock rises, and the process is repeated for millions and millions of years. The result is erosion of more than 10 km worth of sediment from the top of the ancient Appalachians, although the chain was slowly uplifting to compensate, and the deposition of a massive volume of rock that was converted by nature into the Coastal Plain.

The Upper (western) Coastal Plain was created from a combination of fluvial deposition and marine deposition during the Cretaceous and Paleogene Periods. These pebbles, sands, silts, and clays contain a variety of interesting and exotic fossils, including marine reptiles like mosasaurs and plesiosaurs, and occasionally a dinosaur.[4] Shark teeth, bivalves, gastropods, and echinoids are abundant in these layers of sediment as well. The Lower Coastal Plain contains younger fluvial and marine sediments and fossils from the Neogene and Pleistocene. Wave-cut terraces can be found along this portion of the Coastal Plain, running roughly parallel to the modern shoreline and marking earlier high-stands in sea level. Neogene fossils present in these strata include a vast array of shark teeth, including gigantic teeth of *Carcharocles megalodon*, as well as abundant bivalves, gastropods, echinoids, and microfossils.

[4] These dinosaurs almost certainly died while on land, perhaps drowning in a river, and their carcass was transport by river into a shallow marine environment through a process delightfully named "bloat and float".

The Atlantic Coastal Plain widens as it crosses to the south into Virginia and the Carolinas. While multiple battles took place on the province's western flank, including the Seven Days and Bentonville, surprisingly few major conflicts occurred in the interior of the Coastal Plain (Table 1.1). Struggles along the coastline and Fall Zone marked most of the regions of conflict on the Coastal Plain until Union General Sherman captured Atlanta and began to move east.

1.3.2 Western Theater of War

The easternmost portion of the Western Theater of War comprises the southernmost extension of the Piedmont, Blue Ridge, and Valley and Ridge Provinces. The Piedmont and Blue Ridge cross northern Georgia and Atlanta before terminating in central Alabama, where they are surrounded to the south by the Coastal Plain. The Coastal Plain penetrates the center of the continent to the north along the axis of the Mississippi River and stretches laterally to the west into central Texas, Arkansas, and Missouri. The sediments and weak rock composing this province continue their trend of getting older towards the contact with the Piedmont and younger towards the coastline. In Mississippi, for example, Cretaceous sediments and fossils can be found in the northeastern part of the state, Eocene sediments and fossils comprise a band of strata running through the center of the state, and Pliocene sediments are found closer to the Gulf of Mexico.

The northeastern-most extension of the Coastal Plain into the central interior of the United States is located near the junction of Missouri, Tennessee, Kentucky, and Southern Illinois. Many important engagements took place in this region because of the number of strategically important rivers and rail lines. These conflicts include Island Number 10 and Forts Donelson and Henry; Shiloh, Corinth, and Memphis are only slightly farther away.

While the western portion of Tennessee has several battlefields on sandy Coastal Plain sediments, the eastern portion of the state, underlain primarily by much older carbonate rocks, witnessed even more fighting. Carbonates from the Cumberland Plateau (the southern extension of the Appalachian Plateau province) and the Valley and Ridge Province underlie Stones River, Chickamauga, Chattanooga, Nashville, and Franklin. Central Tennessee is geologically dominated by a carbonate central dome (or Nashville Dome). Here the Ordovician limestones have been uplifted and fractured, and this broken rock weathers quickly forming a 20,000 km^2 semicircular basin that spans the state. At the center of the basin, where the formations are dipping the least, is the Stones River battlefield. Rocks farther from Stones River and the flat inner basin dip away from the center of the dome, producing rings of ridges where the carbonates are harder or not as fractured. These ridges were important in the bloody Confederate defeats at Nashville and Franklin.

In eastern Tennessee, the junction of the Valley and Ridge and Cumberland Plateaus provided interesting geology that influenced the fighting for Chattanooga. Differential weathering, combined with folding of the strata, produced two dissimi-

Table 1.1 Major campaigns of the Civil War and the province(s) in which they were conducted

Campaign	Duration	Primary province	Subordinate province
First Manassas	July 16–22, 1861	Piedmont (Mesozoic Basins)	
Fort Henry and Donelson	February 6–16, 1862	Nashville Basin (Low Plateaus Section—Western Highland Rim)	Coastal Plain
Mississippi River	February 6, 1862–July 9, 1863	Coastal Plain	Nashville Basin (Low Plateaus Section—Western Highland Rim)
Peninsula	March 17–August 3, 1862	Coastal Plain	
Shiloh	April 6–7, 1862	Coastal Plain	Nashville Basin (Low Plateaus Section—Western Highland Rim)
First Shenandoah (Jackson's) Valley	May 15–June 17, 1862	Valley and Ridge	
Second Manassas	August 7–September 2, 1862	Piedmont (Mesozoic Basins)	Blue Ridge
Antietam (Maryland)	September 3–17, 1862	Valley and Ridge (Great Valley)	Blue Ridge
Fredericksburg	November 9–December 15, 1862	Coastal Plain	Piedmont
Stones River	December 26, 1862–January 4, 1863	Nashville Basin (Inner Basin)	
Vicksburg	March 29–July 4, 1863	Coastal Plain (Loess Hills)	
Chancellorsville	April 27–May 3, 1863	Piedmont	Coastal Plain
Gettysburg	June 29–July 3, 1863	Piedmont (Mesozoic Basin)	Valley and Ridge; Blue Ridge
Chickamauga and Chattanooga	August 16–Nov. 27, 1863	Valley and Ridge	Appalachian Plateau
Red River	March 10, 1864–May 22, 1864	Coastal Plain	
Overland	May 4–June 3, 1864	Piedmont	Coastal Plain
Atlanta (Tullahoma)	May 7–September 2, 1864	Piedmont	Valley and Ridge; Blue Ridge
Petersburg	June 4, 1864–April 2, 1865	Coastal Plain	Piedmont
Second Shenandoah Valley	August 7–November 28, 1864	Valley and Ridge	Blue Ridge

(continued)

Table 1.1 (continued)

Campaign	Duration	Primary province	Subordinate province
Franklin and Nashville	November 17–December 1–16, 1864	Nashville Basin	
Carolinas	February 3–April 26, 1865	Coastal Plain	Piedmont
Appomattox	April 3–9, 1865	Piedmont	

Fig. 1.8 The crest of Lookout Mountain photographed from the north, just below the summit. Hard sandstone is present on the crest of the ridge with softer limestone beneath (lower right). Inset: 12-Pounder Napoleon cannon on the crest of Lookout Mountain overlooking the Tennessee River, Moccasin Point, and Chattanooga. Note erosion resistant sandstone pillar beside artillery piece

lar ridges that were important in the Union campaign to take the city. Lookout Mountain is capped by a durable Upper-Carboniferous sandstone; this hard rock is underlain by more easily weathered and eroded limestones which are exposed on the steep northern face (Fig. 1.8). To the east, Missionary Ridge is also a function of differential weathering. The ridge is capped by Ordovician carbonates interbedded with cherts, producing a more durable rock than the surrounding and weaker, non-enriched limestones (Henderson 2004). Despite the defensive enhancements provided by this geology, Union forces were successful in capturing both positions in late November, 1863, providing a gateway for Sherman's eventual Atlanta Campaign.

While the rocks in the older provinces are hundreds of millions of years old, and the Coastal Plain exposes sediment that are around a hundred million years old near the Fall Line (Zone), the extreme western and southern portions of the Western Theater have the youngest surficial materials in the United States. The ever-meandering Mississippi River is constantly eroding and redeposited sands, silts, and clays. During the Pleistocene vast quantities of windblown silt blew across the massive floodplains, collecting as a thick blanket of loess found under Vicksburg, Mississippi (Fig. 1.9).

Perhaps and even more dynamic environment than the winding Mississippi is found on the edge of the Coastal Plain along the Southeastern and Gulf Coasts. Here the rising seas, beach drift, and storm erosion are relentlessly reshaping the barrier islands, lagoons, deltas, and salt marshes. The result is a landscape that has been reshaped repeatedly in the 150 years since the Civil War, and many significant battle sites have been lost, including Forts Hatteras and Clark on the Outer Banks of North Carolina and Battery Wagner in Charleston, South Carolina. Other sites have been damaged and later partially preserved through engineering—hard stabilization has saved what is left of Fort Fisher, North Carolina, but the coastal landscape today provides a poor visual representation of the ground the men were fighting over in 1865.

Fig. 1.9 Battery De Golyer is underlain by loess, as is the rest of the Vicksburg Battlefield. At Vicksburg the Union artillery tended to be concentrated, while the Confederate guns were spread along the defensive line

1.4 A Brief Geological History of the Eastern United States

A description of the geological history of a region is best started with a short review of the science of plate tectonics. It is also interesting to consider the relative recency of plate tectonics theory in comparison to the historical timing of the Civil War. The modern understanding of how the Earth's surface came to look as it does today was formulated almost exactly a century after Lee surrendered. As a result, it is safe to conclude that even the most scientifically knowledgeable soldiers and commanding officers[5] at the time had no understanding of the larger forces responsible for the shape of the landscape they were battling over.

The underlying theme of plate tectonics theory states that the cool, brittle, outer layer of the planet is broken into a number of moving fragments—or plates—of varying sizes. These lithospheric plates slowly slide around above a warmer, partially melted layer of the Earth called the asthenosphere. Plates are always moving and they can converge on each other, causing collisions that produce mountain ranges, or diverge away from one another, such as at spreading centers. They also grind laterally past one another, producing earthquake-rich regions like southern California.

Plate boundaries are geologically dynamic places. The majority of powerful earthquakes and volcanoes occur along these boundaries and the characteristics of the plate interactions are dictated by the types of plates involved. Plates are also created at plate boundaries; those formed at spreading centers or mid-ocean ridges are composed of ferromagnesian-rich minerals, creating dark rocks like basalt. The largest of these basaltic, or oceanic, plates is the Pacific plate, which was created at a mid-ocean ridge called the East Pacific Rise. Importantly, ferromagnesian silicate minerals like olivine and pyroxene make these oceanic plates denser than other plates that lack these heavy minerals. In contrast, continental (or granitic) plates are composed of rocks created from non-ferromagnesian silicate minerals like quartz and feldspar. As a result, these silica-rich rocks are lighter in color and less dense than those found in basaltic plates.

When oceanic and continental plates collide the differences in density result in subduction of the oceanic plate, a process critically important in the formation of the geological provinces of eastern North America. Subduction occurs when denser oceanic crust slides beneath less dense granitic crust, producing many deep, powerful earthquakes. The plunging oceanic plate also eventually begins to melt in the warmer interior of the planet, producing molten material that often later rises to produce large and powerful volcanoes on the surface.

Almost all of the recent high-intensity earthquakes (e.g. Sumatra, Tohoku, Maule) and volcanoes (e.g. Mt. St. Helens, Mt. Pinatubo) occur in subduction zones

[5] Of all higher ranking Commanding Officers on either side of the conflict, only one had any type of geological training or background. William Rosecrans, who led the Union Army of the Cumberland at Stones River and Chickamauga, studied geology before the war and was a successful oil, coal, and mining executive.

and although the eastern United States is not in an area of plate collision today, it has repeatedly been in the past.

The Atlantic seaboard marks the edge of the North American continent, but not the edge of the North American plate. As with most plates, the North American plate is a combination of continental and oceanic rocks. The true edge of the plate is in the middle of the Atlantic Ocean, where new crust is forming along the Mid-Atlantic Ridge, a massive 15,000 km-long seafloor spreading center. North America is being pushed by this separating ridge away from Europe and Africa at a rate of a few centimeters per year.[6]

From a geological perspective, the Atlantic Ocean is relatively young, having been created only with the break-up of the supercontinent Pangea. Pangea, the most recent supercontinent created when plate tectonics pushed all the continents together, existed from 340 to 175 million years ago. To study the history of the United States east of the Mississippi, however, an earlier supercontinent called Rodinia must first be discussed.

The oldest rocks in the east were formed when Rodinia was created by the Grenville Orogeny (mountain building event) during the Middle Proterozoic, around one billion years ago. Sedimentation, volcanism, and plutonism were widespread during this period of time, and the entire region that would become the core of North America was slowly being uplifted. When Rodinia began to split apart around 700 million years ago, fractures in the crust formed great rift basins that were eventually filled with sediment by rivers flowing down from the highlands. These sediments lithified into hard sedimentary rocks that were eventually metamorphosed, uplifted, and fractured. Despite their profound age, these ancient rocks can still be seen in portions of the Blue Ridge Province, including the Great Smokey Mountains.

This crustal rifting also produced a phenomenon called bimodal volcanism, where lava flows and igneous intrusions produced basalt and, concurrently and on a larger scale, massive volumes of granitic magma crystallize deeper underground. The complete rifting of Rodinia didn't occur until just over 600 million years ago, when a new ocean was created that would be significant in the history of eastern North America: the Iapetus.

Rodinia had rifted into two smaller, but still massive, supercontinents. Laurentia, which would evolve in part into North America, and Gondwana, which would eventually become Africa and South America. A mid-ocean ridge pushed these continents apart for around 100 million years, producing a relatively quiet time for the portions of the Earth that would eventually become North America. During the Cambrian and Ordovician Periods, a massive carbonate platform, similar to the modern Caribbean, developed in the Iapetus over much of this same area. The sandy shores of Laurentia eventually hardened into tough sandstones, and later metamorphosed quartzites, that survive today in the rock that cap many monadnocks.

Around 500 million years ago the expansion rate of the mid-ocean ridge separating Gondwana and Laurentia began to decrease before tectonic forces reversed the

[6] Don't be surprised if American Airlines begins to add a surcharge to ticket prices to cover this increasing distance on international flights.